

# Phonon Recycling for Ultrasensitive Kinetic Inductance Detectors

Completed Technology Project (2016 - 2019)



## Project Introduction

Initially proposed (Day et al. 2003; Zmuidzinas 2012) in 1999 by our Caltech/JPL group, and thanks to strong support from NASA, the superconducting (microwave) kinetic inductance detector (MKID or KID) technology continues to develop rapidly as it transitions into applications. The development effort worldwide is intensifying and NASA's continued support of KID development is essential in order to keep pace. Here we propose to investigate and demonstrate a new, low-TRL concept, which we call phonon recycling, that promises to open broad new avenues in KID design and performance. Briefly, phonon recycling allows the detector designer to tailor the responsivity and sensitivity of a KID to match the needs of the application by using geometry to restrict the rate at which recombination phonons are allowed to escape from the detector. In particular, phonon recycling should allow very low noise-equivalent power (NEP) to be achieved without requiring very low operating temperatures. Phonon recycling is analogous to the use of micromachined suspension legs to control the flow of heat in a bolometer, as measured by the thermal conductivity  $G$ . However, phonon recycling exploits the non-thermal distribution of recombination phonons as well as their very slow decay in crystals at low temperatures. These properties translate to geometrical and mechanical requirements for a phonon-recycled KID that are considerably more relaxed than for a bolometer operating at the same temperature and NEP. Our ultimate goal is to develop detector arrays suitable for a far-infrared (FIR) space mission, which will impose strict requirements on the array sensitivity, yield, uniformity, multiplexing density, etc. Through previous NASA support under the Strategic Astrophysics Technology (SAT) program, we have successfully demonstrated the MAKO submillimeter camera at the Caltech Submillimeter Observatory and have become familiar with these practical issues. If our demonstration of phonon recycling is successful, we will have a path for continuously adapting the high-background, high-NEP detectors we have demonstrated on the ground to the ultralow-NEP detectors needed for space.



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## Organizational Responsibility

### Responsible Mission Directorate:

Science Mission Directorate  
(SMD)

### Responsible Program:

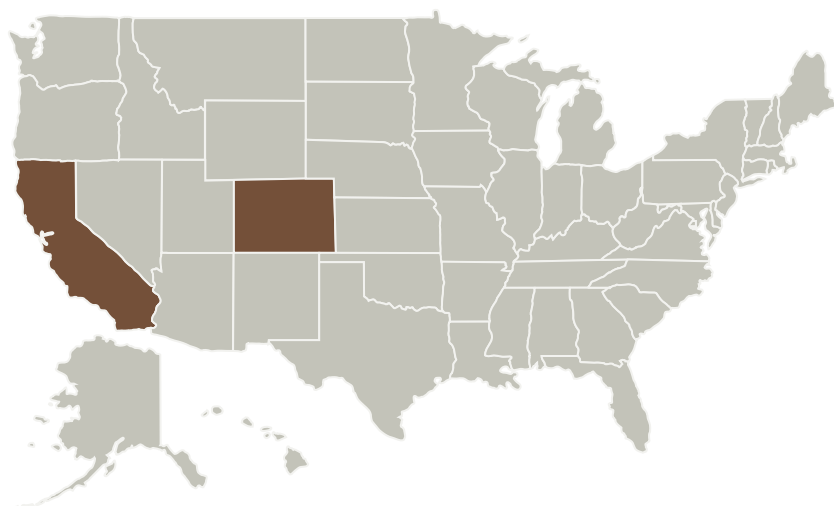
Astrophysics Research and  
Analysis

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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology (CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations	
California	Colorado

## Project Management

**Program Director:**

Michael A Garcia

**Program Manager:**

Dominic J Benford

**Principal Investigator:**

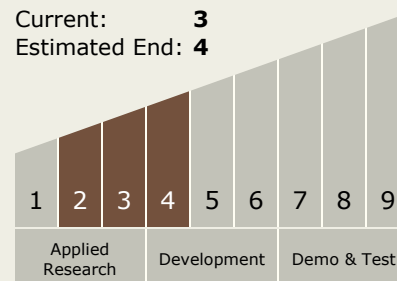
Jonas Zmuidzinas

**Co-Investigators:**

Henry G Leduc  
 Christopher M Mckenney  
 Lucy A Viramontes  
 Peter K Day  
 Jason Glenn

## Technology Maturity (TRL)

Start: 2  
 Current: 3  
 Estimated End: 4



## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

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## Target Destination

Outside the Solar System